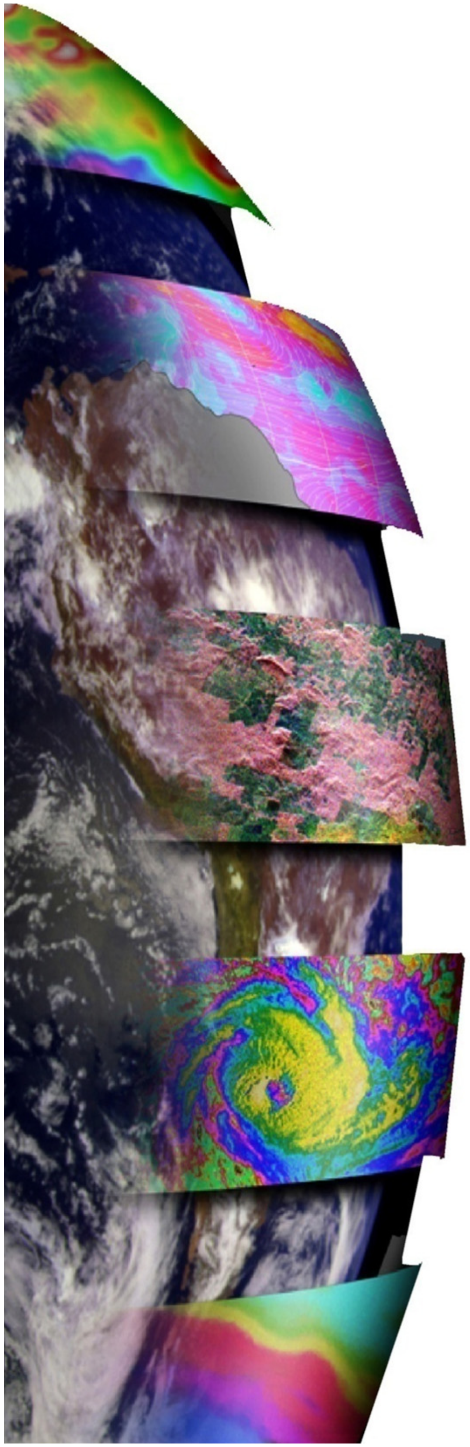
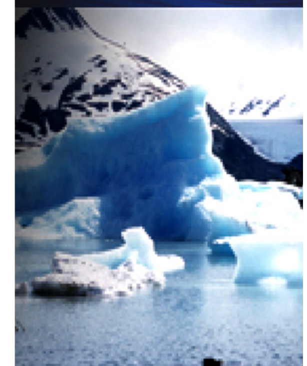
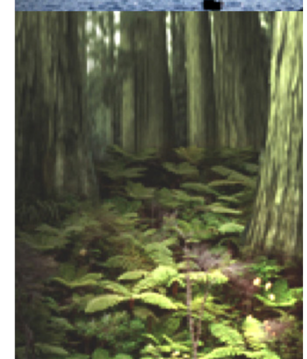


Remote Sensing for Climate and Environmental Change

Dr. Diane Evans
Director for Earth Science and Technology
Jet Propulsion Laboratory
California Institute of Technology

March 20, 2011
PIERS
Progress in Electromagnetics Research Symposium
Marrakesh, Morocco





Decadal Survey* Priorities

Observations

Analyses
Forecasts
Models

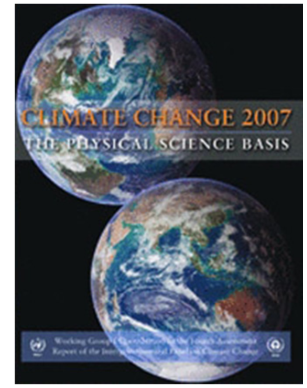
Decision
Processes

Taking responsibility for developing and connecting these three elements in support of society's needs represents a new social contract for the scientific community.

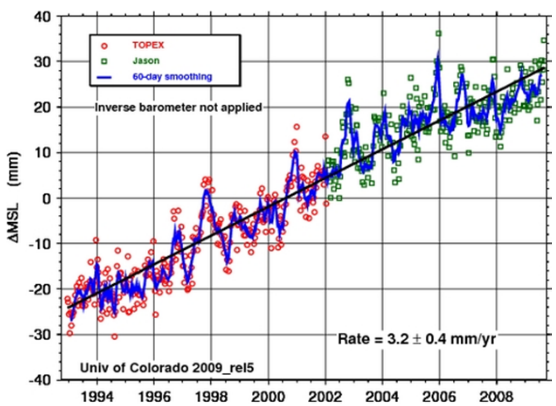
generating scientific observations and conducting research →	transforming results into useful information →	distributing information to public and private sector managers, decision-makers, policy-makers, and the public at large

* Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond Committee on Earth Science and Applications from Space: A Community Assessment and Strategy for the Future

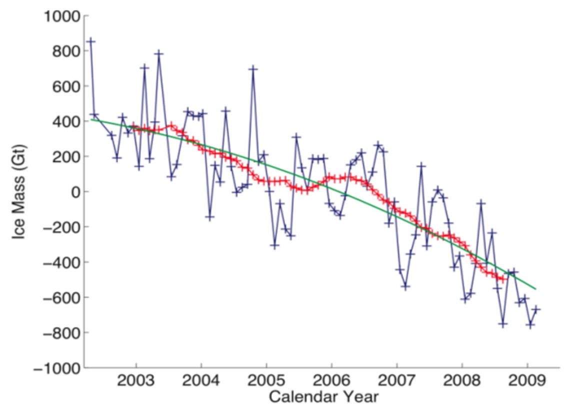
Role of Satellites in Global Change



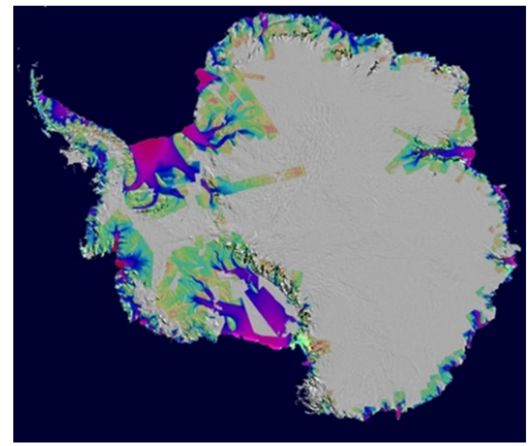
Direct Observations



Altimetry
Sea Level Rise
1992-2009
(Nerem, 2009)

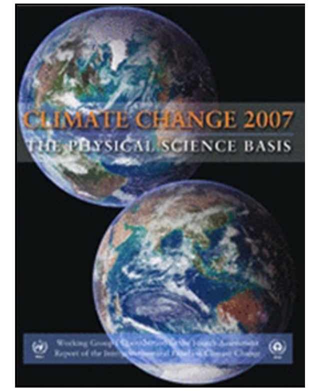


GRACE
Antarctic ice loss
2002-2009
(Velicogna, 2009)



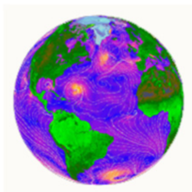
InSAR
Antarctic ice loss
1996-2006
(Rignot, 2008)

Role of Satellites in Global Change

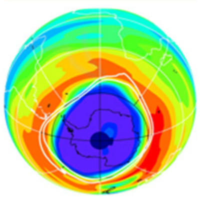


Minimizing Uncertainties in Models

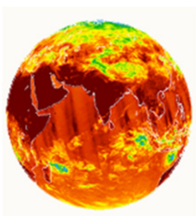
QuikScat
Winds



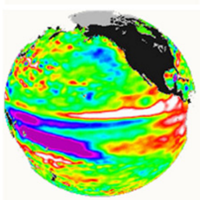
MLS
Temp /
water vapor



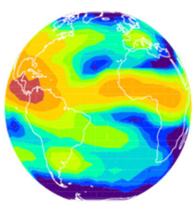
AIRS
(Temp/water
Vapor)

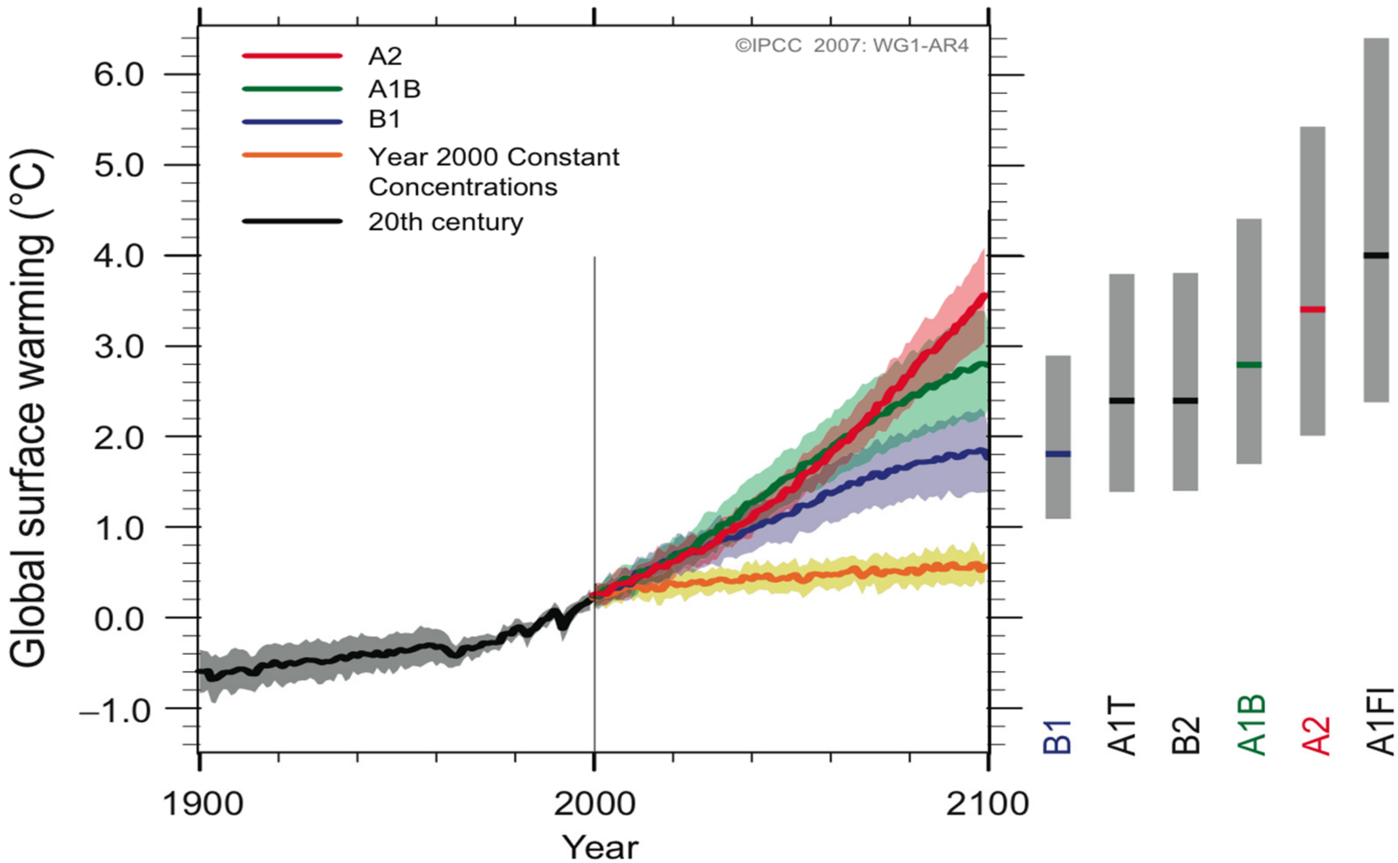


Jason
(Sea Surface
Height)

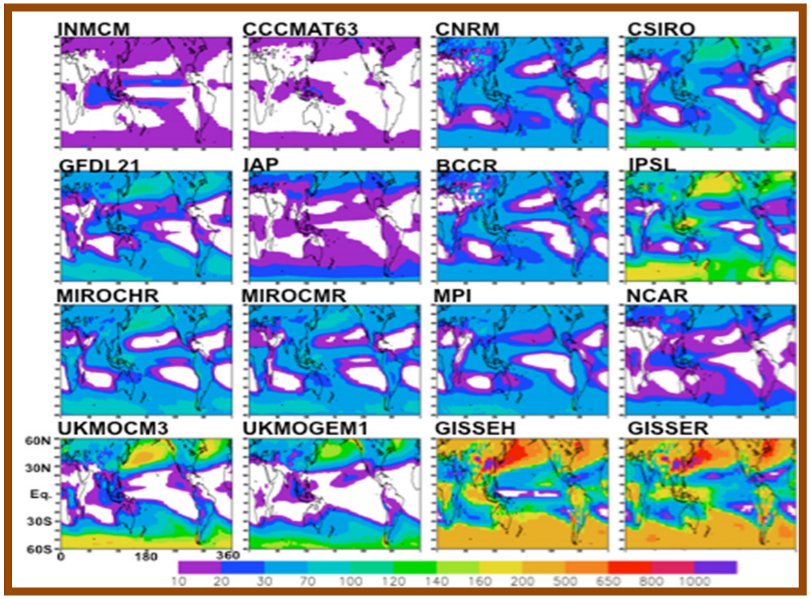


CloudSat
(cloud ice)

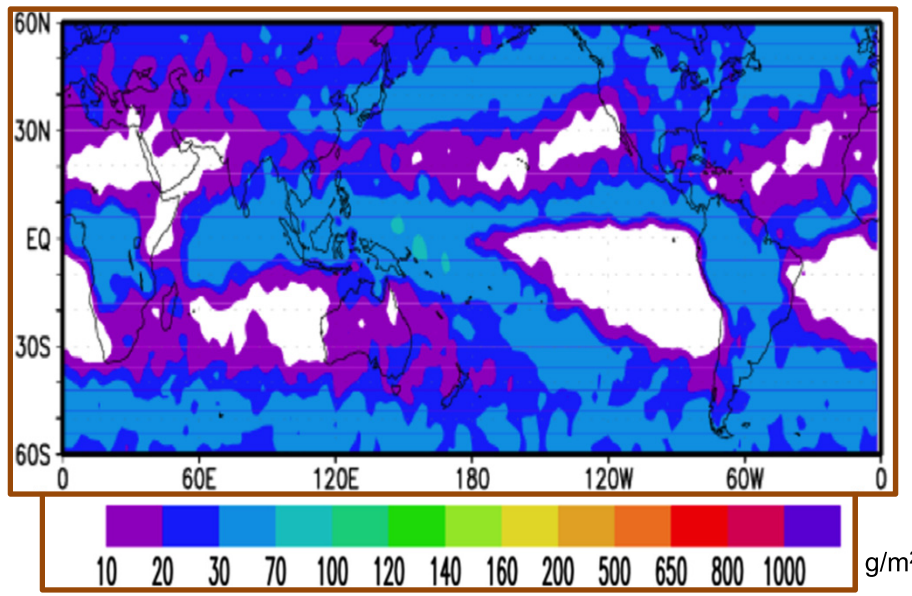




Model-Data Comparisons for IPCC Assessment



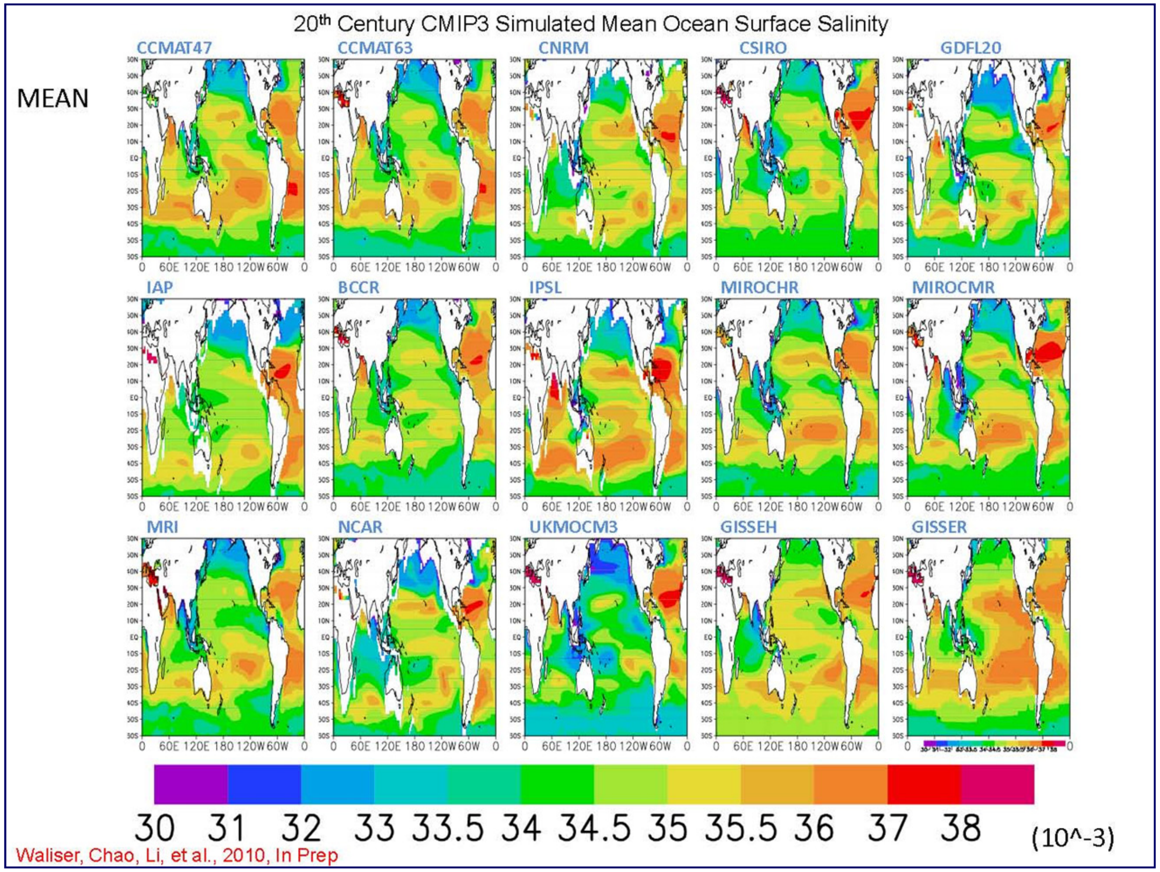
Estimates of Cloud Ice Concentrations from Models Used in the IPCC 4th Assessment



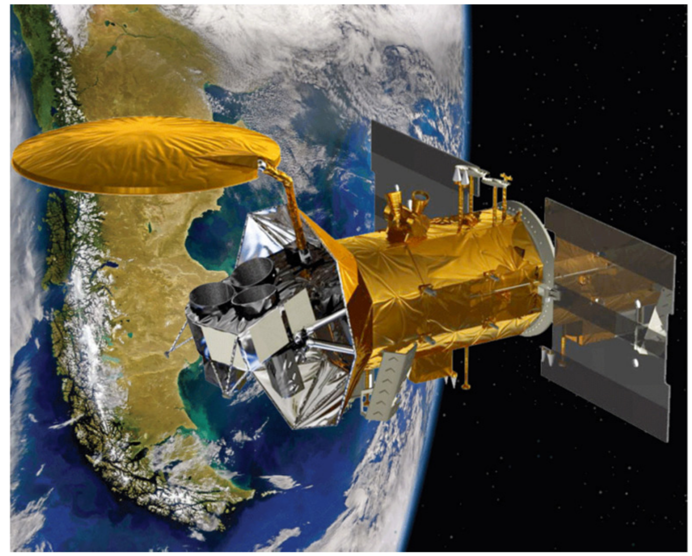
Actual Global Ice Concentrations Observed by CloudSat

Waliser (2009)

Aquarius Measurements of Sea Surface Salinity



Mean *Salinity* from 12 CMIP3 Model Simulations of 20th Century Climate: POOR MODEL AGREEMENT

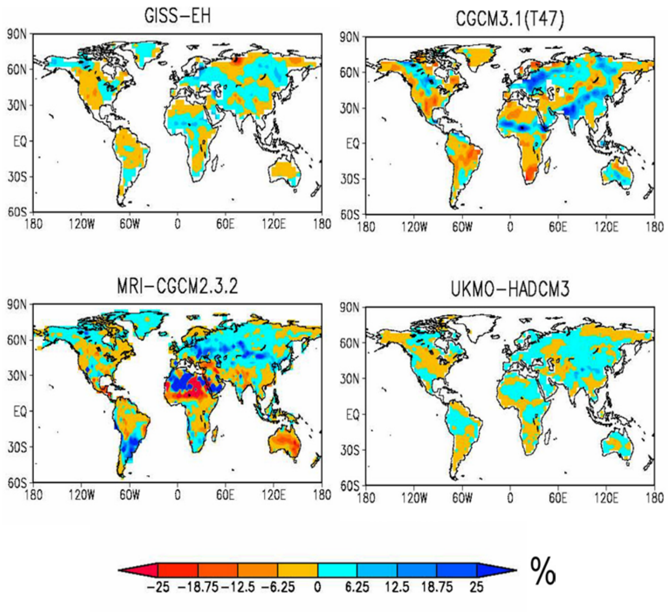


Aquarius will use an L-band radar (JPL) and radiometer (GSFC) to make monthly maps of sea surface salinity with precision of 0.2 PSU (.2 gkg^{-1}) and resolution of 150 x 150 km

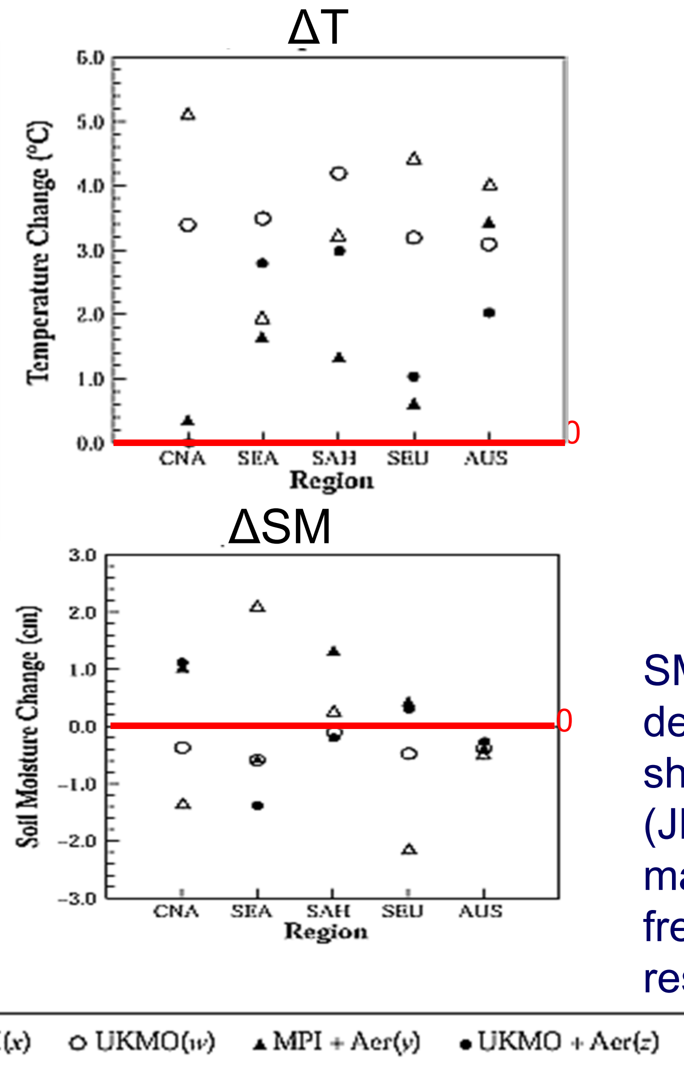
Partners: CONAE (INPE, ASI, CNES, CSA)

LRD: 06/09/2011

Soil Moisture Active and Passive (SMAP)



Li et al., (2007)



SMAP will use a rotating 6-m deployable mesh antenna shared by an L-band radar (JPL) & radiometer (GSFC) to map soil moisture and freeze/thaw state with 10 km resolution every 3 days

LRD: 11/2014

History of Climate Model Intercomparison

1989 – Inception of DOE PCMDI (Program for Climate Model Diagnostics & Intercomparison)

1990-1995 - The Atmospheric Model Intercomparison Project (**AMIP**)

30 Atmospheric GCMs perform a common experiment (prescribed SST & sea-ice), standardized output

1995-2000 –

AMIP II – tighter experimental protocol, more extensive diagnostics — gigabytes

The Coupled Model Intercomparison Project (**CMIP**) — megabytes

AMIP & CMIP were highlighted in 2nd & 3rd IPCC Assessment Report (SAR-1995, TAR-2001)

2000 – 2003 - The Coupled Model Intercomparison Phase II - CMIP2 — gigabytes

2003 – Present - The Coupled Model Intercomparison Phase III - **CMIP3** — terabytes

- About 75% of the more than 100 figures in IPCC AR4 Chapters 8-11 are based on CMIP3 results.
- 4 of the 7 figures appearing in the IPCC "Summary for Policy Makers" are based on CMIP3

CMIP3 formed the model basis for the 4th IPCC Assessment Report (FAR-2007)

2009 – Present - The Coupled Model Intercomparison Phase V - **CMIP5** — (projected) petabytes

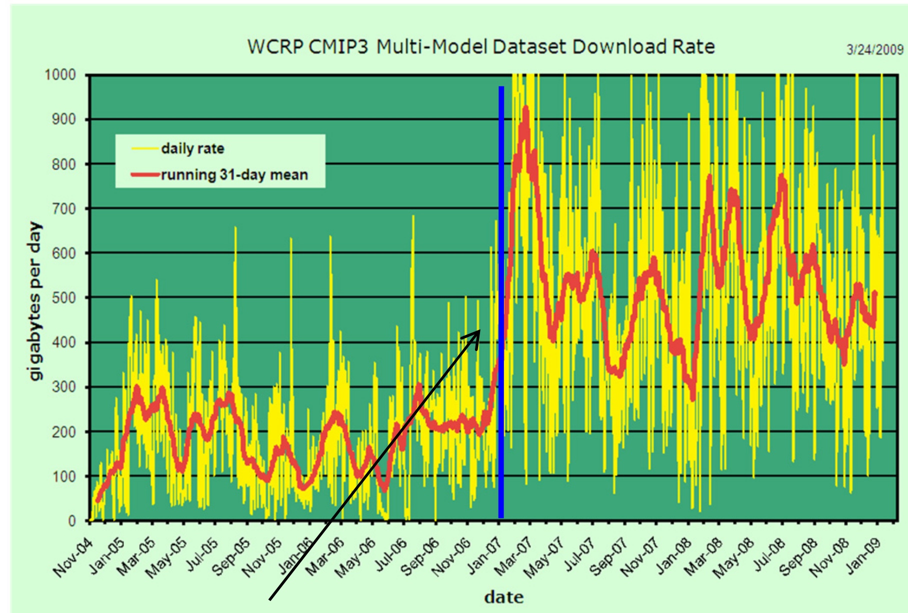
CMIP5 will form the model basis for the 5th IPCC Assessment Report (AR5-2013)

CMIP Resource, Research and Impacts

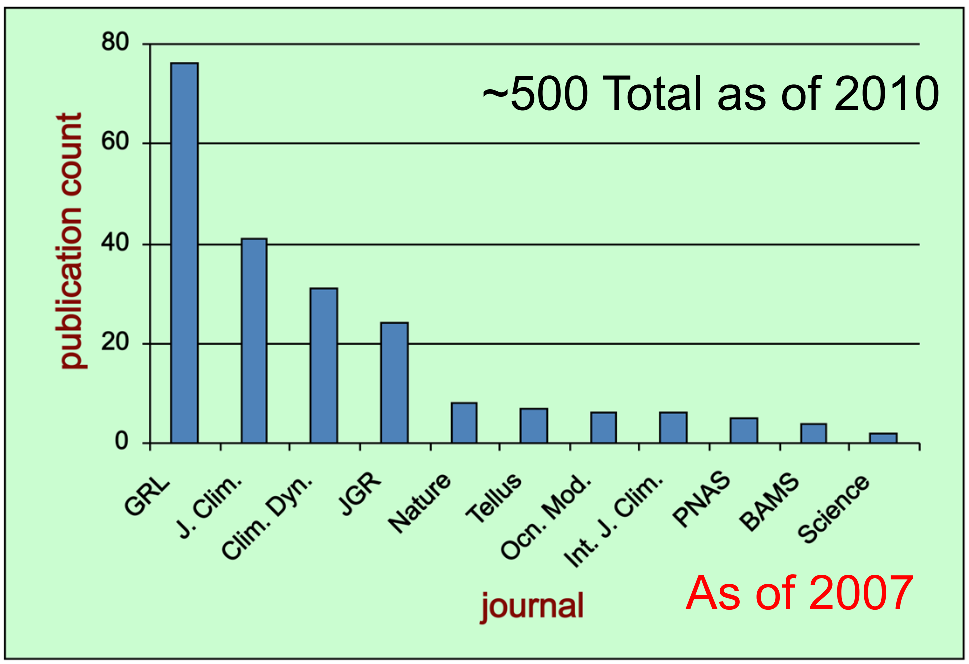
What made the difference in CMIP3/AR5?

<u>An investment in infrastructure and standards</u>

- Community-developed metadata convention
  “Climate-Forecast” (CF)
- Software to ensure model data compliance:
  The Climate Model Output Writer (CMOR)
- State-of-the-art data delivery methods
  The Earth System Grid (ESG)



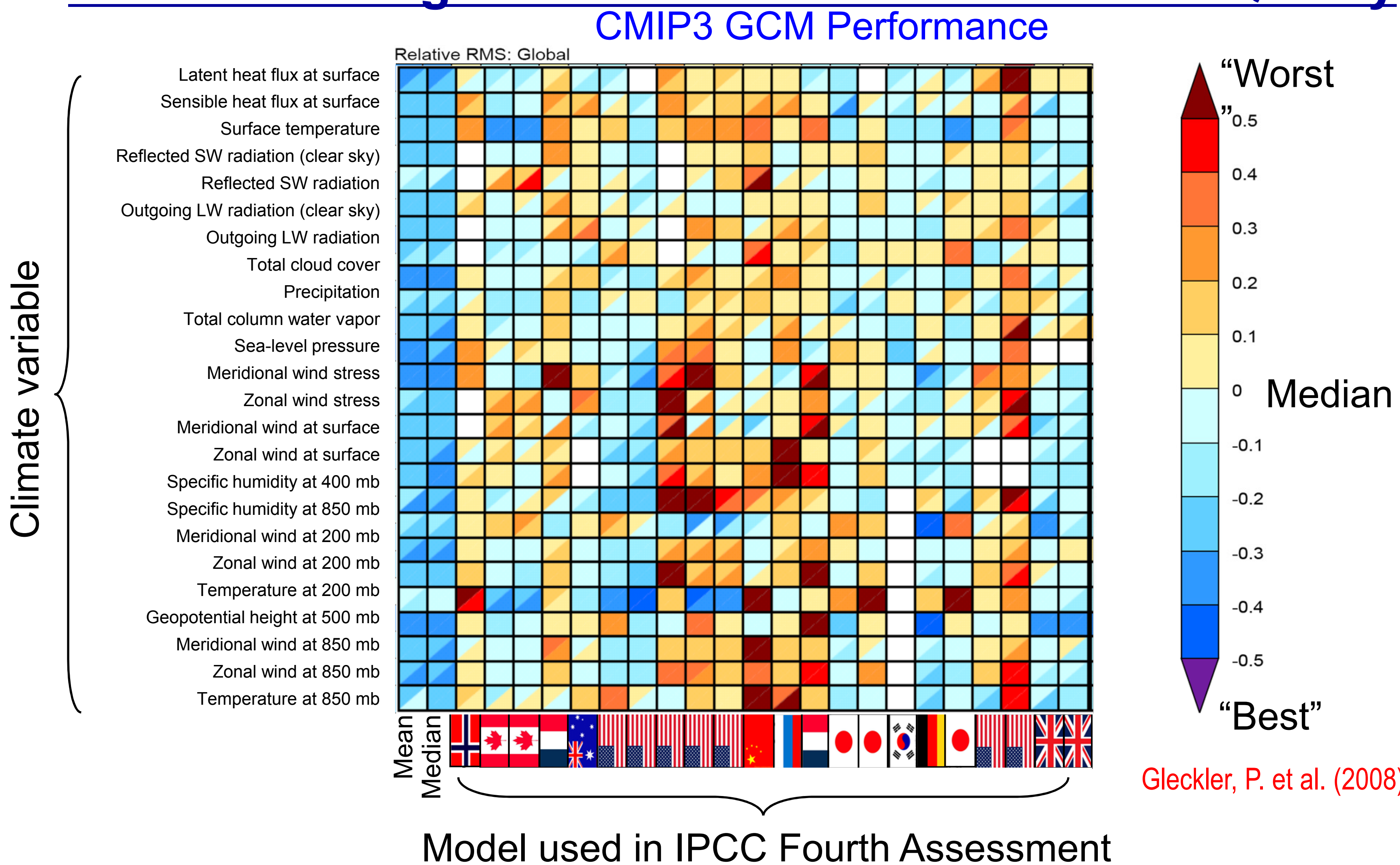
IPCC AR4
published



Number of registered users: **2570**
Dataset Size: **36 Terabytes** in 83,000 files
Amount downloaded: **536 Terabytes** in
1,781,000 files

IPCC AR5 - New Emphases, Opportunities, & Needs:

Model "Scoring" Based on Measures of Model Quality



Gleckler, P. et al. (2008)

New WGCM & WGEN Metrics Subpanel: Use observation-based "metrics" to assess model representations of past climate -> use to weight models' climate projections

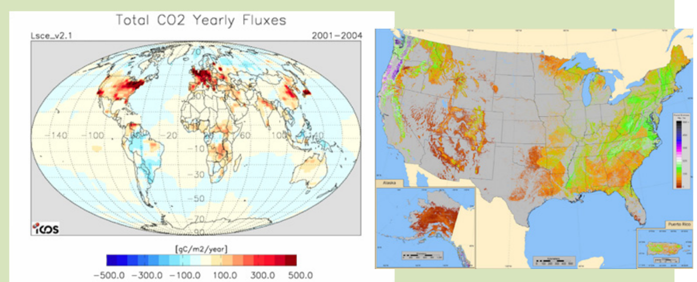
Carbon/GHG focus

Greenhouse Gas Information System (GHGIS)

- Grassroots effort started in 2008 by JPL and partners at DOE labs, NOAA, & NASA for climate policy/treaty support
- Since expanded to engage over 30 US agencies, universities, NGOs, and international partners
- Scoping study underway for an integrated global monitoring system (surface & space)

NASA Carbon Monitoring System (CMS)

- New congressional mandate for policy support
- NASA's response
  - 2 Pilot Projects (global & US)
  - Scoping Study for future system
- Actively exploring additional pilot projects



Information Systems Flow

Are FF emissions from individual point sources exceeding reported values?

How are individual FF point sources being operated (dynamic behavior)?

Are Country-A's total GHG emissions exceeding their reported values?

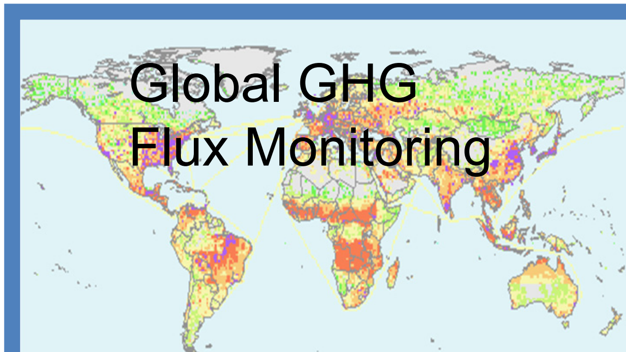
Are area-source (AFOLU) emission estimates for a given region accurate?

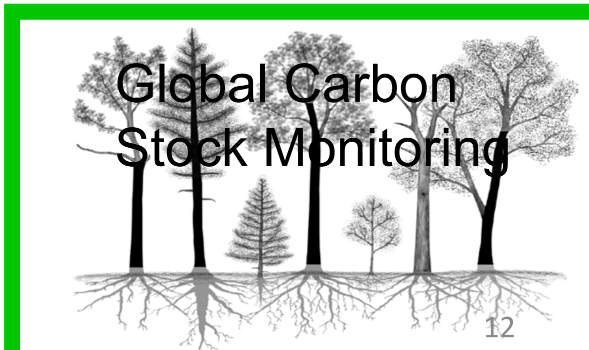
If policy X isn't meeting its ultimate objective, what needs adjustment? Where?

Is Project-Y's claimed baseline for a forest carbon offset credit real?

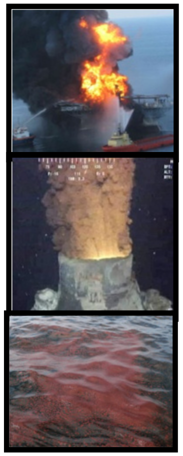
Are disturbances occurring that impact Country-B's claimed carbon credits (is the offset permanent)?

And how good is good enough (re: uncertainty)?

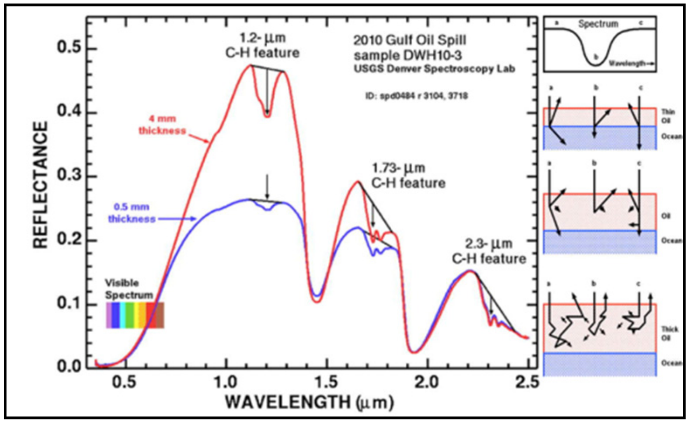




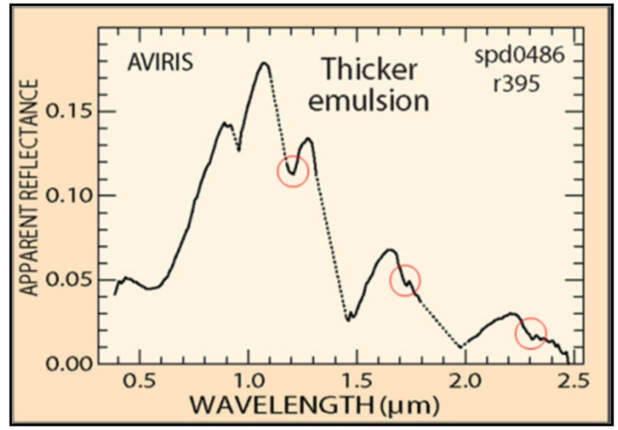
Imaging spectroscopy used by NASA, USGS, and NOAA to estimate thickness and volume of surface oil



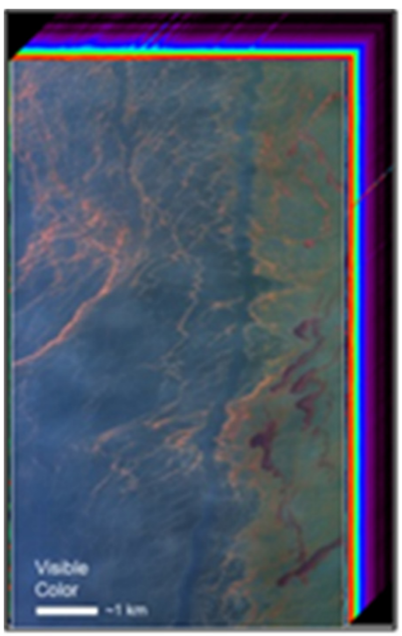
Spectroscopic Basis: Infrared C-H Bond Absorptions



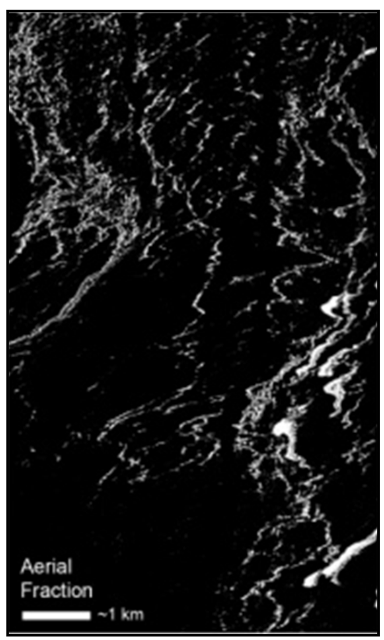
NASA AVIRIS Spectra from the Gulf



AVIRIS Gulf Measurements



Surface Fraction



Thickness

Quantitative Volume Estimates

AVIRIS Run 11: 677 samples x 16835 scanlines
249214 pixels mapped out of 11397295 total image pixels.

	Thickness (mm)			Volume (liters/pixel)			Pixels
Oil:H2O	cons.	aggr.	poss.	conserv.	aggress.	possible	Mapped
92: 8	0.10	0.10	0.10	1109.7	1109.7	1109.7	171
92: 8	0.50	0.50	20.00	10714.7	10714.7	428586.0	609
92: 8	1.50	1.90	20.00	229802.3	291082.9	3064030.3	2467
92: 8	2.00	4.00	20.00	9229.2	18458.4	92291.9	72
80:20	1.00	1.50	20.00	330680.6	496020.9	6613611.8	7861
75:25	1.50	1.50	20.00	28007.7	28007.7	373436.1	855
60:40	0.01	0.03	0.03	2.2	4.5	4.5	9
60:40	0.03	0.05	0.05	47.5	95.0	95.0	125
60:40	0.10	0.10	0.10	69.2	69.2	69.2	65
60:40	0.50	0.50	0.50	14560.4	14560.4	14560.4	2062
60:40	1.50	1.90	1.90	37030.2	46904.9	46904.9	2882
60:40	2.00	4.00	20.00	122918.2	245836.4	1229182.2	5027
40:60	0.03	0.05	0.05	0.0	0.0	0.0	0
40:60	0.10	0.10	0.10	2.1	2.1	2.1	8
40:60	0.50	0.50	0.50	288.5	288.5	288.5	208
40:60	1.50	1.90	1.90	875.5	1108.9	1108.9	150
40:60	2.00	4.00	20.00	5926.9	11853.8	59268.8	822
23:77	0.01	0.03	0.03	0.2	0.3	0.3	3
23:77	0.03	0.05	0.05	0.4	0.9	0.9	7
23:77	0.10	0.10	0.10	6.2	6.2	6.2	23
23:77	0.50	0.50	0.50	4505.3	4505.3	4505.3	3613
23:77	1.50	1.90	1.90	12498.6	15831.5	15831.5	2865
23:77	2.00	4.00	20.00	2649.6	5299.2	26495.8	450
6:94	1.00	3.00	3.00	3311.4	9934.2	9934.2	3036
1:99	0.10	1.00	1.00	2.4	24.0	24.0	170
1:99	1.00	20.00	20.00	284.5	5690.9	5690.9	720
1:99	0.10	1.00	1.00	110.1	1101.1	1101.1	6948 low level
60:40	0.08	0.16	0.16	34050.3	68100.7	68100.7	19295 low level
60:40	0.06	0.12	0.12	295113.0	590226.1	590226.1	188691 trace

Total volume found:
1143797 liters (conservative) = 7194 barrels
1866838 liters (aggressive) = 11742 barrels
12646467 liters (possible) = 79543 barrels

Courtesy Rob Green (JPL)

<u>A</u>dvanced <u>R</u>apid <u>I</u>maging <u>A</u>nalysis

"Nature creates hazards, but the actions or inactions of people, societies and governments create disasters"

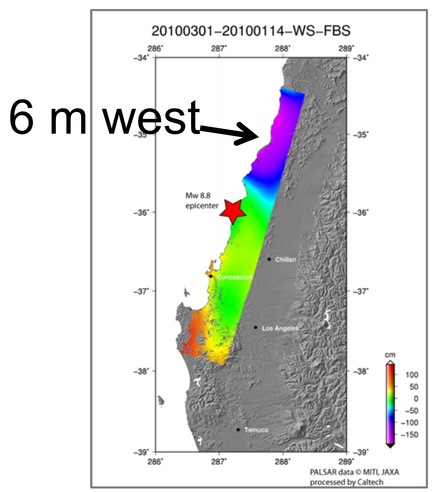
<u>*Objective*</u>

Build an end-to-end prototype system enabling near-real-time earthquake science, assessment, response, and recovery.

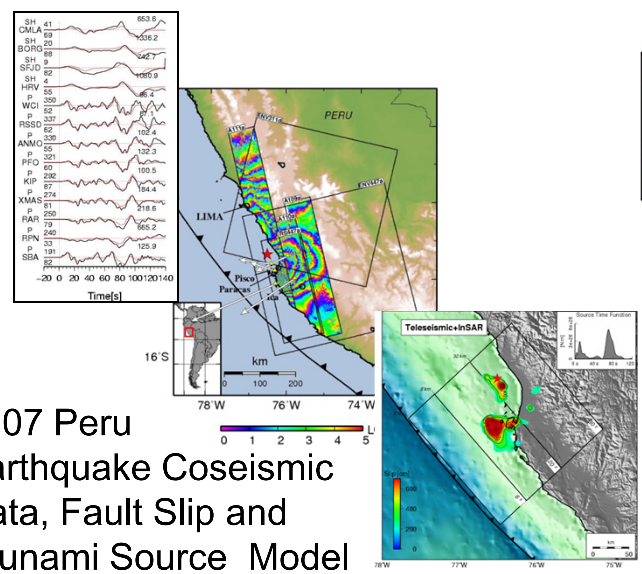
Automate data processing. Reduce latency from weeks to days (InSAR) and days to minutes (GPS).

Integrate InSAR, GPS, seismology, modeling.

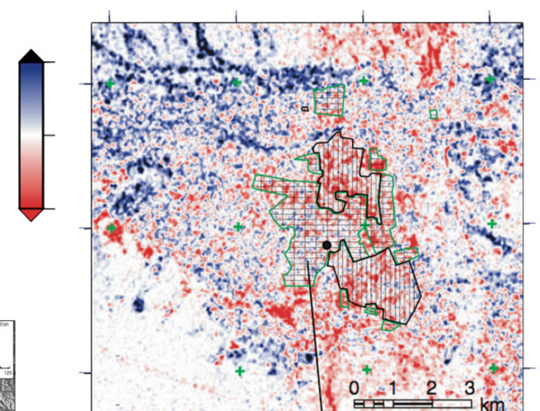
Deliver actionable science products.



2010 M8.8 Chile Earthquake Coseismic Interferogram



2007 Peru Earthquake Coseismic Data, Fault Slip and Tsunami Source Model



2003 Iran Earthquake Decorrelation Map for Rapid Damage Assessment

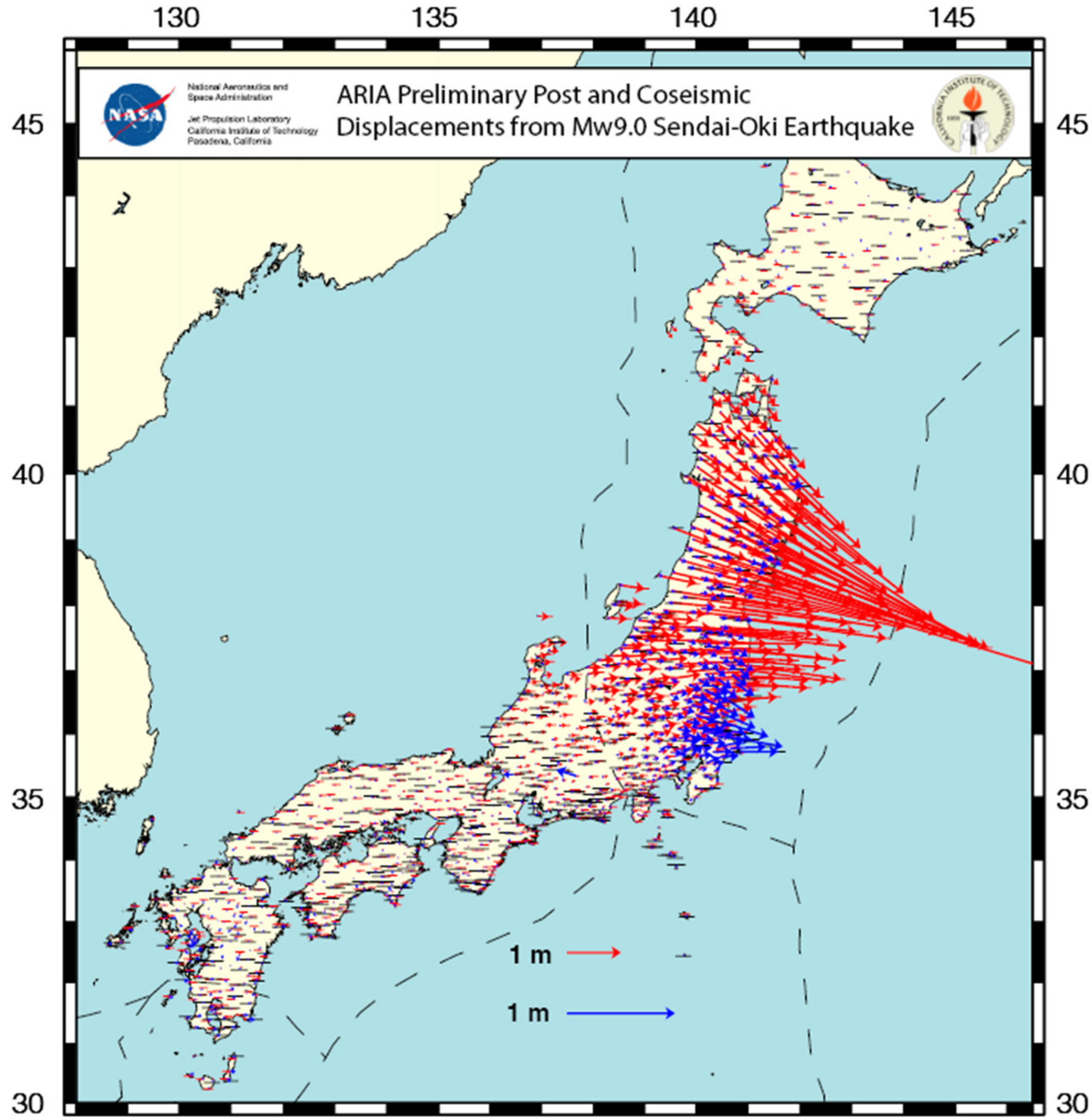


Figure shows horizontal displacements based on ARIA verion 0.3 position estimates for GEONET stations. Coseismic displacement is shown in red, and first 8 hours of postseismic motion is shown in blue, including motion caused by aftershocks. Bars at end of vector show 95% error estimate. Solutions courtesy of ARIA team at JPL and Caltech (email aria@jpl.nasa.gov or aria@caltech.edu). All original GEONET RINEX data provided to Caltech by the Geospatial Information Authority (GSI) of Japan.

Summary

- Remote sensing is being used more and more for decision-making and policy development.
- Specific examples are:
  - Providing constraints on climate models used in IPCC assessments
  - Framing discussions about greenhouse gas monitoring
  - Providing support for hazard assessment and recovery.